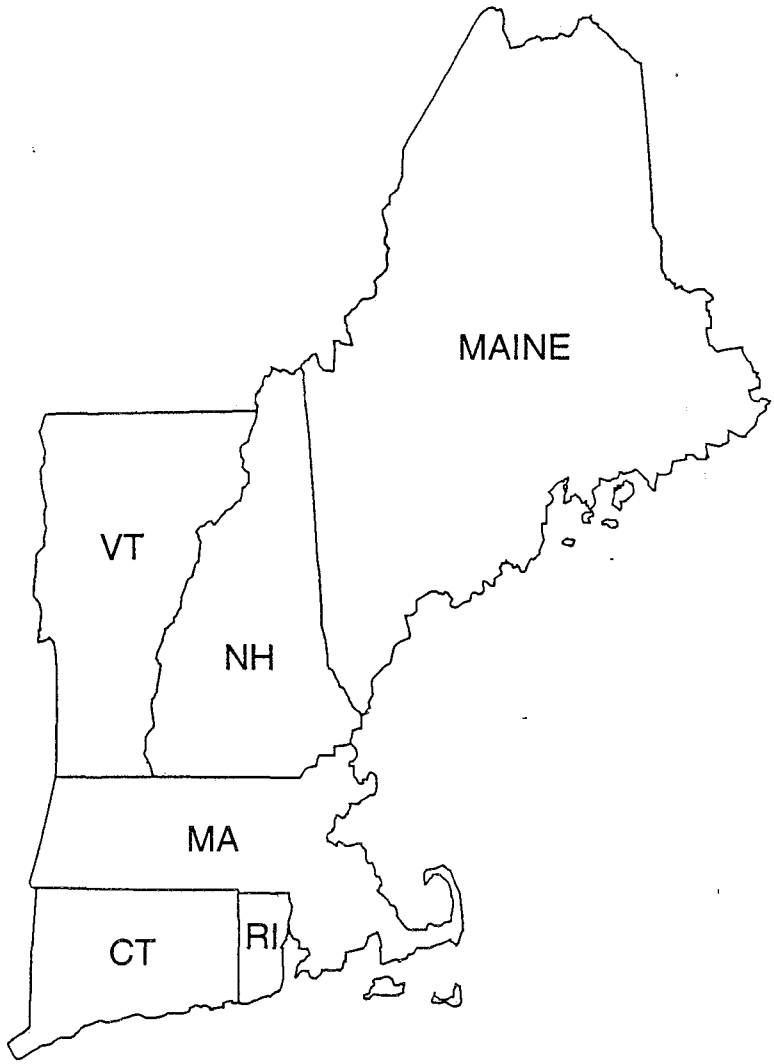
US Army Corps
of Engineers
New England Division

The National Study of Water Management During Drought

The Study of Vulnerability of New England to Drought-Phase I



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This report documents Phase I of the Study of the Vulnerability of New England Drought (The New England Drought Study) which is one of several regional study components or case studies of the National Study of Water Management During Drought (The National Drought Study).

The New England Drought Study is to be conducted in the six New England states (ME, NH, VT, MA, RI, and CT) in two phases over a three year period beginning in FY 91. Phase I is devoted to the selection of an area of concentration and a scope of work for Phase II. Selection is based on the degree of vulnerability to drought, the value of the experience nationally in dealing with drought, and the willingness of the selected state or agency to participate in the study.

The Phase I report recommends that the Massachusetts Water Resource Authority/ Metropolitan District Commission (MWRA/MDC) be the principal focus for Phase II of the New England Drought Study. It is also recommended that all of the New England states be associated with Phase II, since all can enrich and benefit from the study.

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The National Study of Water Management During Drought

STUDY OF THE VULNERABILITY OF NEW ENGLAND TO DROUGHT

PHASE I

EXECUTIVE SUMMARY

This Study of the Vulnerability of New England to Drought (The New England Drought Study) is one of several regional study components or case studies of the National Study of Water Management During Drought (The National Drought Study). The principal objective of the National Drought Study is to review how water is managed in the United States, to engage the water management community in a number of case studies on specific approaches to the problem and to develop a strategy to improve water management during drought. A manual would be produced indicating several models for the preparation for droughts. Additionally a drought atlas would be prepared.

The National Drought Study is being conducted under the authority of Sections 707 and 729 of the Water Resources Development Act of 1986. Section 707 entitled, "Capital Investment Needs for Water Resources", authorizes the Secretary of the Army for Civil Works to prepare and submit to Congress an estimate of the long term capital needs for water resources programs under his jurisdiction. Section 729 regarding the "Study of Water Resources Needs of River Basins and Regions" authorizes the Secretary of the Army for Civil Works, in coordination with the Secretary of the Interior and in consultation with appropriate Federal, State, and local agencies, to study the water resources needs of river basins and regions of the United States.

The National Drought Study is the Corps of Engineers response to the droughts that occurred throughout the United States from 1986 to 1988 and which persist in some regions today. The study is conducted out of the Corps' Institute for Water Resources in Ft. Belvoir, Va. with William Werick as the Manager of the study team. The plan of study was developed by Corps senior staff and four water managers from outside of the Corps through a series of questionnaires and workshops. The New England area, among others, was subsequently selected for a case study.

The case studies are required to satisfy two objectives:

- to help achieve the principal objective of the National Drought Study or to develop a better way of managing drought in the United States,
- to leave the region better prepared for drought.

The New England Drought Study is to be conducted in the six New England states (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut) in three phases over a three year period beginning in FY 91. Phase I is devoted to the selection of an area of concentration and a scope of work for Phase II. Selection is based on the degree of vulnerability to drought, the value of the experience nationally in dealing with drought, and the willingness of the selected state or agency to participate in the study.

In early 1990, the Assistant Secretary of the Army (Civil Works) wrote to the governors of the 50 states eliciting their perspectives on drought issues and requesting their participation in and points of contact for the drought study. The responses to the Secretary's letter is the point of departure for the New England Drought Study.

Phase I involved discussions with each of the points of contact in the six New England states and other Federal, State and local officials and the collection of data and information and its analysis relative to the three selection criteria. The study found that although there have been periods of persistent dryness, no serious drought, or otherwise water shortage has visited New England since the 1960's. However during periods of low rainfall there are regions in all of the New England states that are vulnerable to drought. The uses at highest risk are municipal and industrial water supply, crop and livestock production, and wastewater assimilation. Because of the large number of people impacted by water shortages in urban water supply systems or system failures, municipal and industrial water supply throughout New England, and particularly those in the highly urbanized area of Massachusetts, Rhode Island and Connecticut, is the most vulnerable use to water shortages.

An initial response to the 1960's drought has been the improvement of water supply systems for rural and urban populations, crops and livestock and later the completion of comprehensive planning studies to develop new sources of water. Attempts to implement some of the recommendations of these studies has been met with resistence from rural populations, other states sharing a common water resource, environmental groups, and Federal, state, and local enforcement agencies. Meanwhile changes in Federal laws such as the Safe Drinking Water Act and wetlands legislation have excluded certain water resources from future development or require additional investment for their development.

A more recent response to potential shortfalls in water supply for urban areas has been decisions on the part of several New England states to apply water supply and demand measures in order to deliver more water from existing sources and to reduce demand through conservation thus obviating the need to immediately develop new sources. Massachusetts, Connecticut, and Rhode Island are at different stages in implementing the required legislative, policy, and institutional foundations of their water supply and demand programs. The Massachusetts Water Resources Authority/ Metropolitan District Commission (MWRA/MDC) is the largest wholesaler of potable water in New England and serves approximately 2.5 million people primarily in the greater Boston area. It draws its principal sources of water through interbasin transfers from the Connecticut (Quabbin and Ware River Watersheds) and Merrimack River basins. These basins historically have endured the longest periods of drought in the region.

The MWRA/MDC system is typical of many urban communities in New England, in the northeast or elsewhere in the United States with water sypply systems whose infrastructures are old, lacking in redundancy, nearing the safe yield of their supplies, facing increased demands and in need of capital improvements.

The MWRA has agreed to be the object of Phase II of the study. The study would basically trace the MWRA/MDC water resources planning experience as it responded to the 1960's drought by investigating new sources of supply, met resistance to the development of new sources, and as it responded to this resistance by adopting strategic, drought contingency, and emergency planning techniques, including supply and demand management, which obviated the need for new supplies. A logical extension of this experience is the development of a trigger planning process to identify and schedule the required activities for ensuring that future water supplies are adequate to satisfy demand.

More specifically Phase II would focus initially on the description, analysis, enhancement from other national experience, and finally developing a prototype of the MWRA/MDC strategic, drought contingency and emergency water resources planning experience. In addition, other water supply systems would be identified where the model could be selectively applied. Another focus of the study would be to work with MWRA/MDC staff to develop trigger planning techniques to identify, schedule and implement decisions and activities that are prerequisites to ensuring that future water supplies are adequate in quantity, quality, and reliability to meet future demand.

The MWRA/MDC experience may be selectively applicable to other urban areas in New England and elsewhere in the United States, and particularly in the northeast with similar features of aging water systems and lack of redundancy, which are laboring under political, regulatory, technical, legal, etc., constraints in planning to meet the changing demands for municipal and industrial water supply.

It is recommended that the MWRA/MDC be the principal focus for Phase II of the New England Drought Study. It is also recommended that all of the New England states be associated with Phase II, since all can enrich and benefit from the study. In particular, Rhode Island and Connecticut have adopted similar approaches as the MWRA/MDC in enhancing the quantity of water delivered from existing sources and in modulating demand through conservation.

GLOSSARY OF ABBREVIATIONS

CT - Connecticut

DEM - Department of Environmental Management (Massachusetts)

DEP - Department of Environmental Protection (Connecticut and Massachusetts)

DES - Department of Environmental Services (New Hampshire)

DPUC - Department of Public Utility Control (Connecticut)

MA - Massachusetts

MDC - Metropolitan District Commission (Massachusetts)

ME - Maine

MEMA - Maine Emergency Management Agency

MGD - Million Gallons Per Day

MWRA - Massachusetts Water Resources Authority

NED - New England Division, Corps of Engineers

The National Drought Study - The National Study of Water Management During Drought

The New England Drought Study - The Study of the Vulnerability of New England to Drought

NH - New Hampshire

OPM - Office of Policy and Management (Connecticut)

RI - Rhode Island

VT - Vermont

WRCC - Water Resources Coordinating Council (Rhode Island)

DEFINITION OF TERMS

The following definitions have been extracted from the The National Study of Water Management During Drought - Report on the First Year of Study (May 1991)

DROUGHT is the widespread negative economic, social and environmental impacts because there is less water than expected. The shortfall can be a result of lack of precipitation, water systems deficiency or failure, contamination, etc.

WATER MANAGEMENT is the planned intervention in the hydrologic cycle in order to enhance water uses and reduce water hazards. Water management during drought refers to intervention in the hydrologic cycle in both anticipation and response to drought for the purpose of reducing adverse impacts of drought.

THE NEW ENGLAND DROUGHT STUDY

TABLE OF CONTENTS

EXECUTIVE SUMMARY
GLOSSARY OF ABBREVIATIONS
DEFINITION OF TERMS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF ATTACHMENTS

I - INTRODUCTION

BACKGROUND

The Study of the Vulnerability of New England to Drought (The New England Drought Study) is one of a number of regional study components or case studies in the National Study of Water Management During Drought (The National Drought Study). The authority under which this study is conducted requires the preparation of estimates of long term capital needs for water resources programs under the jurisdiction of the Secretary of the Army for Civil Works. The principal objective of the National Study is to review the ways that water is managed in the United States, engage the water management community in a number of case studies over specific approaches to the problem and develop a strategy to improve water management during drought. A manual would be undertaken on how to prepare for drought as well as recommendations made to effect policy changes as appropriate. Also a drought atlas would be prepared.

The National Study is a Corps of Engineers response to the droughts that occurred throughout the United States from 1986 to 1988 and which continue in some regions today. The plan of study was developed by Corps' senior staff and four water managers from outside of the Corps through a series of questionnaires and workshops. These were designed to find the greatest regional concerns with respect to water management during drought and then to develop a plan of study to address there concerns.

In addition, the Assistant Secretary of the Army (Civil Works), Robert Page, wrote to the governors of the 50 States, and Federal Agencies in early 1990 with drought responsibilities eliciting their perspectives on drought issues and requesting their participation in and points of contact for the drought study. The point of departure for The New England Drought Study is the responses from the six New England States to the Assistant Secretary's letter.

STUDY AUTHORITY

The National Drought Study is being conducted under the authority of Sections 707 and 729 of the Water Resources Development Act of 1986. Section 707 entitled, "Capital Investment Needs for Water Resources", authorizes the Secretary of the Army for Civil Works to prepare and submit to Congress an estimate of the long term capital needs for water resources programs under his jurisdiction, including but not limited to:

- deep draft ports
- inland waterway transportation
- flood control
- municipal and industrial water supply
- hydroelectric power
- recreation
- fish and wildlife conservation

Section 729 regarding the "Study of Water Resources Needs of River Basins and Regions" authorizes the Secretary of the Army for Civil Works, in coordination with the Secretary of the Interior and in consultation with appropriate Federal, State and local agencies, to study the water resources needs of river basins and regions of the United States.

STUDY AREA

The study area for The New England Drought Study is comprised of the six New England States: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont.

STUDY OBJECTIVE

The New England region was selected as one of the case studies for the National Drought Study for several reasons. It represents an area of the country that has not experienced serious widespread drought since the 1960's and may be due for one. Also New England has a number of water supply systems that are typical of a large number of urbanized communities in the United States with aging municipal and industrial water supply infrastructures, and perhaps lacking redundancy, which are not only in need of capital improvements, but must face the challenges of satisfying new demands. These challenges are to be confronted in an environment which only supports the development of new supplies as one of last resort and which imposes water quality and environmental requirements that exclude the development of certain potential sources or make their development more expensive.

The case studies must satisfy two objectives:

"to help achieve the principal objective of the National Study of Water Management During Drought, which is to develop a better way to manage water during drought in the United States;

to leave the region better prepared for drought."[1/]

SCOPE OF WORK

The New England Drought Study is to be conducted over a three year period beginning in FY 91. The work during Phase I is directed to the selection of State/s and/or region/s for the conduct of Phase II and to a determination of the scope of the effort for Phase II. Selection is based on the degree of vulnerability to drought, the value of the experience nationally in dealing with drought and the willingness of the selected states or agency staff to participate in the study. See Attachment A for the scope of work for Phase I.

1/ U.S. Army Corps of Engineers, Institute for Water Resources, National Study of Water Management During Drought, Report of the First Year of Study, May 1991, page B-1.

PRIOR REPORTS

- The U.S. Army Corps of Engineers, Institute for Water Resources (IWR), The National Study of Water Management During Drought - Report of the First Year of Study, May 1991 incorporates the results of the following four studies prepared for the National Drought Study.

- Corps of Engineers, Davis, California, Hydrologic Engineering Center, A Preliminary Assessment of Corps Reservoirs, Their Purposes, and Susceptibility to Drought, September 1991.

- Planning and Management Consultants, Ltd.; Carbondale, Illinois, Water Management During Drought; Research Assessment, August 1991.

- Advisory Council on Intergovernmental Relations, Washington, DC, Intergovernmental Coordination for Drought Related Water Resources Management, 1990.

- Resources for the Future, Washington, DC, Integrated Framework for a National Water Management Under Drought Study.

II - THE NEW ENGLAND REGION

LAND, POPULATION AND CLIMATE

The Six New England States occupy approximately 1.8 percent of the national area with a population of nearly 13 million in 1988 or 5.3 percent of the U.S. population. New England is part of a densely populated and highly urbanized area in northeastern United States, which extends from southern New England to Virginia and is known as a megalopolis or huge urbanized area. Population density in New England ranges from approximately 39 inhabitants per square mile in Maine to 941 in Rhode Island compared to a national average of 70. See Map No.1 and Table No 1. The degree of urbanization varies from 23 and 36 percent of the populations in Vermont and Maine to over 90 percent in Rhode Island, Connecticut and Massachusetts compared to New England and national averages of approximately 80 and 78 percent. But New England exhibits a certain dualism: rural and sparsely settled communities existing throughout New England and concentrated in the three northern states of Maine, New Hampshire and Vermont and the urbanized and densely populated areas characteristic of Massachusetts, Rhode Island and Connecticut.

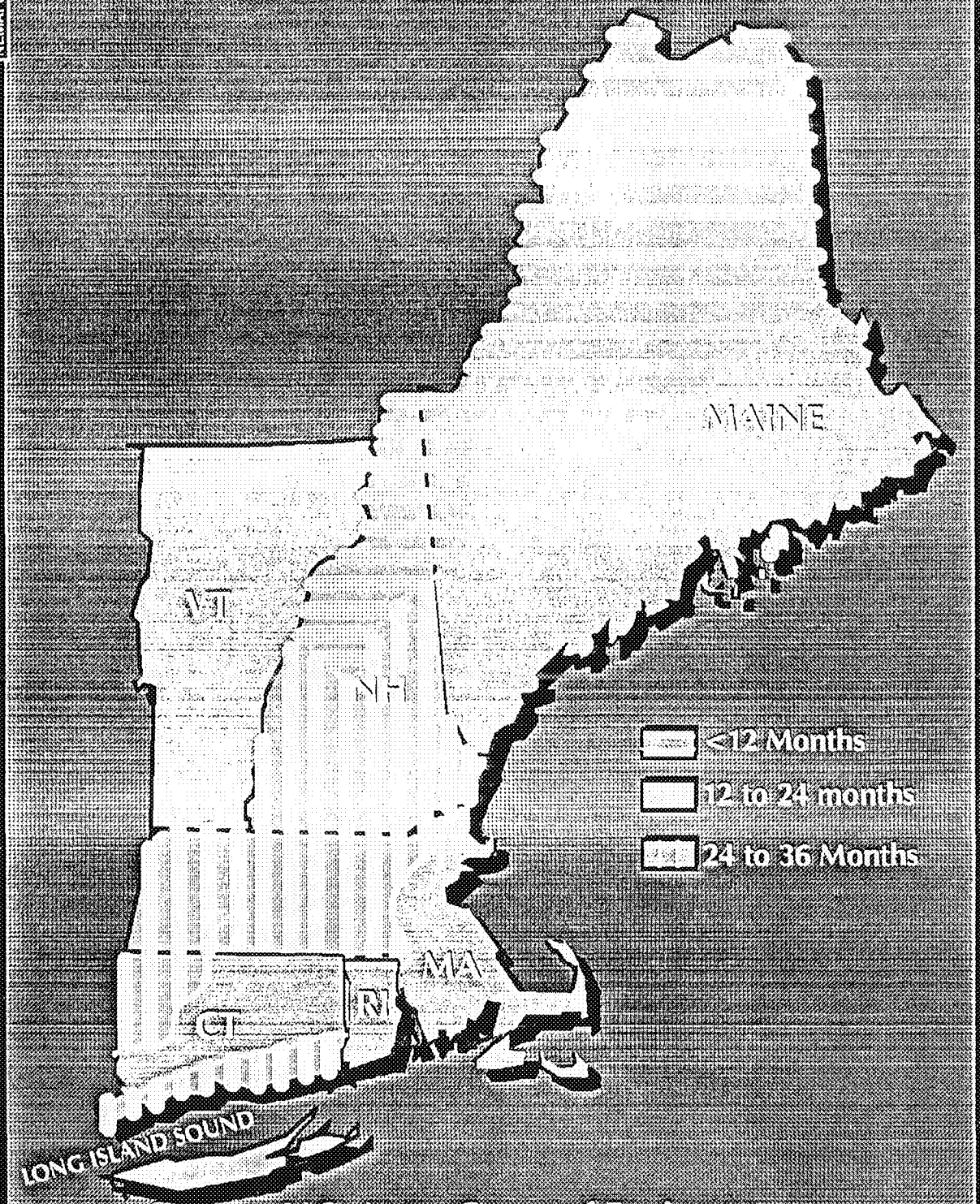
Map No.2 indicates variations in annual rainfall in New England from 30 to 40 inches in northern Vermont and northern Maine to 46 to 48 inches in coastal Maine to Connecticut. The most notable droughts in New England in terms of duration, magnitude, and geographical extent occurred between 1908-1914, 1946-1950 and 1963-1967. With respect to historical drought severity within New England, Map No.3 indicates drought durations of less than 12 months in northern Maine and northern New Hampshire and the longest durations between 24 to 36 months in southern New Hampshire, central and western Massachusetts and northwestern and southern coastal Connecticut. Although the Boston Metropolitan climatological vulnerability demonstrates severest droughts between 12 to 24 months, the principal source of its municipal and industrial water supply is situated in the portion of the Connecticut River Basin which has experienced drought of 24 to 36 months duration.

Water rights in the New England states are based on riparian doctrine. Riparian rights provide for the equal sharing of water by those owning land abutting water resources. There are substantial differences in how the states apply riparian law. These vary from those where riparian law is more purely applied such as Maine, New Hampshire, Vermont, and Rhode Island to those that have adopted statutes based on appropriation law (first in time is first in right) that require permits for certain uses of surface water such as Massachusetts and Connecticut. The trend in water law in New England seems to be a movement towards appropriation doctrine.[1/]

1/ Wright, Kenneth R. (Editor) - Water Rights of the Fifty States and Territories, American Water Works Association, Denver, Colorado, 1990.

NEMAP024.IMG 07/8/91 MEC

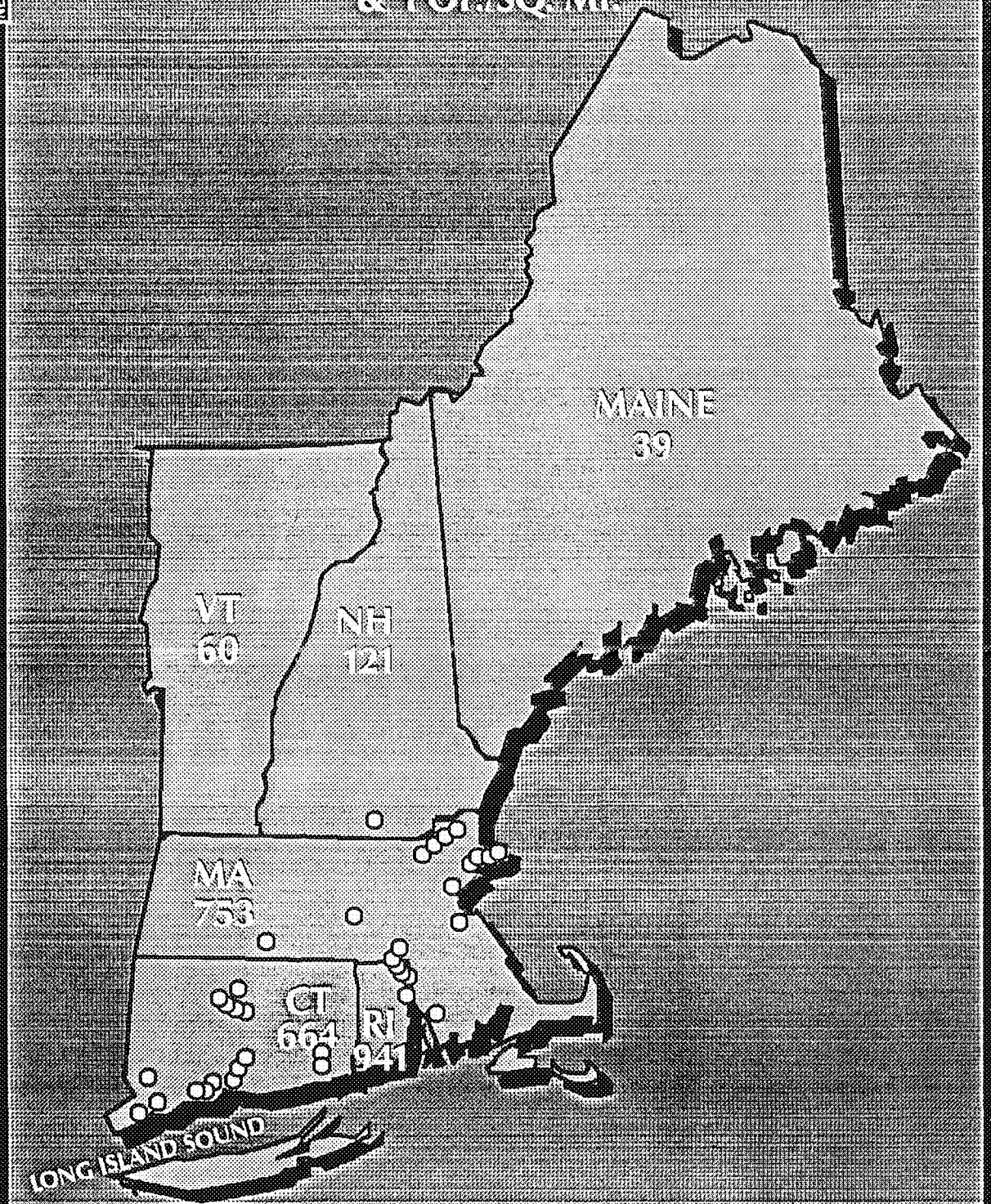
MAP NO. 3
NEW ENGLAND SEVERE DROUGHT DURATIONS BY STATE CLIMATIC DIVISIONS



Source: U.S. Army Corps of Engineers,
Hydrologic Engineering Center
Research Document No. 33 Dec. 1990

NEMAP022.IMG 07/1991 MEC

MAP NO. 1
NEW ENGLAND POPULATION (1988)
METROPLITAN AREAS & CITIES > 100,000 (○)
& POP./SQ. MI.



Source: U.S. Department of Commerce Bureau of Census, Statistical Abstract of the United States, 1990

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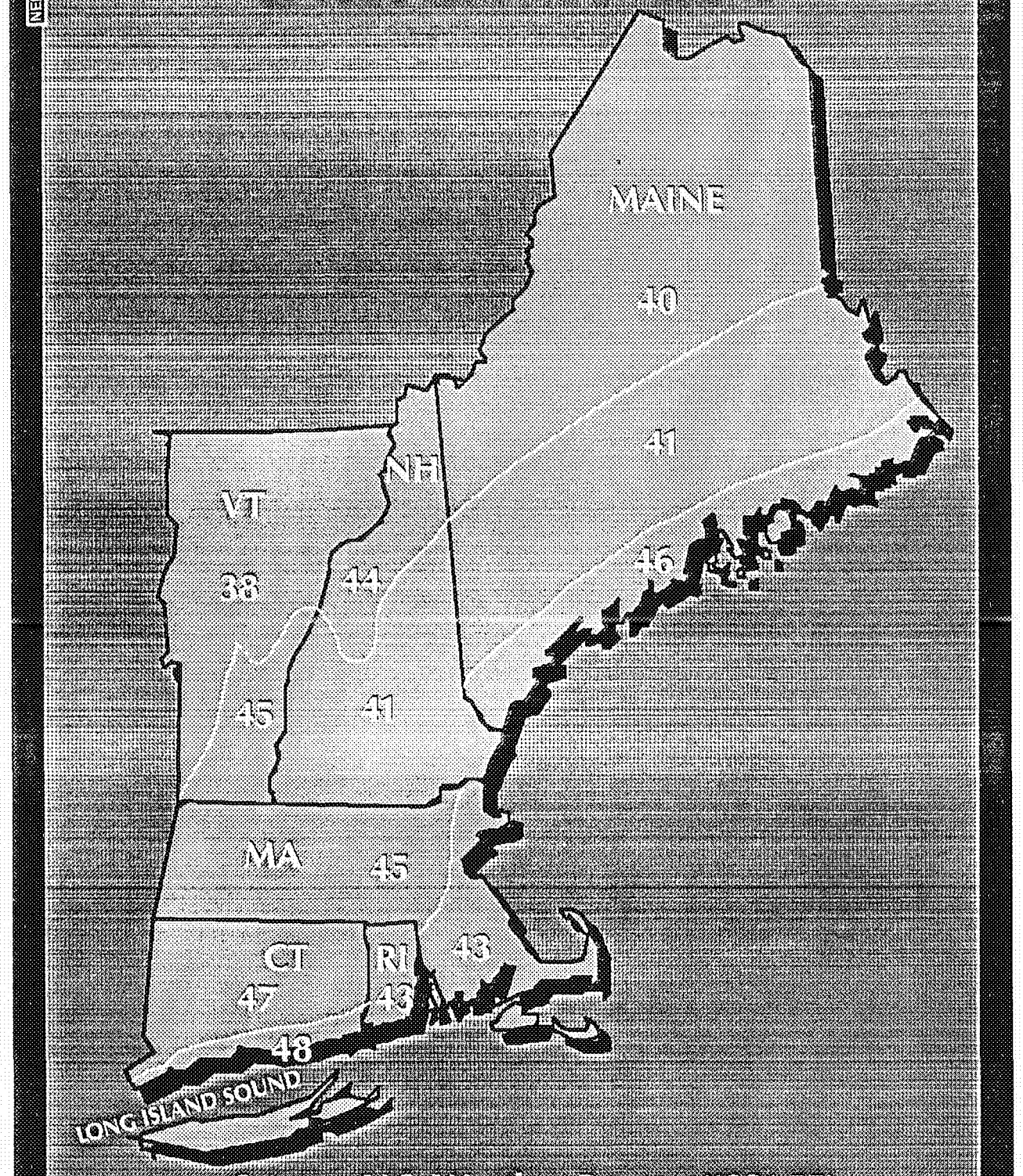
MAP NO. 2
NEW ENGLAND
MEAN ANNUAL TOTAL PRECIPITATION (IN)
BY STATE CLIMATIC DIVISIONS



Source: U.S. Weather Bureau (1931-55)

Northern New England

Northern New England, consisting of Maine, New Hampshire and Vermont, is characterized as rural and sparsely populated although its southern limits resemble the urbanized character of southern New England. Northern New England occupies more than three-quarters of the regional land area with less than one-quarter of the New England population. See Table 1. Nashua, New Hampshire is the only metropolitan area with more than 100,000 inhabitants. See Map No.1 and Table No.2. Northern New England is generally considered to be water rich but the sub-region is only water-rich compared to the relatively modest demands on its water resources.

Southern New England

In contrast, southern New England has more than three-quarters of the regional population occupying less than one-quarter of the land. Here the urbanized population constitutes over 90 percent of the population which is clustered in the areas designated in Map No. 1. In terms of the degree of urbanization Rhode Island, Connecticut and Massachusetts respectively rank fifth, sixth and ninth in the U.S. See Tables 1 to 4. Rhode Island, Connecticut and Massachusetts respectively rank third, fourth and fifth of States, including the District of Columbia, in highest population densities in the United States. In fact, the top eight states with the highest population densities are clustered in northeastern United States between Massachusetts and Delaware. Southern New England's demands on regional water resources are a reflection of the magnitude of its large population. The location of these populations and their need for water resources is a source of conflict between urban dweller's immediate needs and rural inhabitants future requirements.

Another facet of the conflict is along State lines with some states desiring to conserve interstate resources such as the Connecticut River and others opting for the early development of the resource. Inhabitants of Connecticut, New Hampshire, and Vermont have joined communities in western Massachusetts and other interest groups in constraining metropolitan Boston's efforts to increase its withdrawals of water from the Connecticut River Basin.

Table No. 1

CHARACTERISTICS
NEW ENGLAND (NE) AND POPULATION (1988)

	Area (mi^2)	Population (1000)	% Total	Population per mi^2	Percent Population in Metropolitan Areas
ME	33,265	1,205	9.3	38.9	36.1
NH	9,279	1,085	8.4	120.7	56.3
VT	9,614	557	4.3	60.1	23.2
MA	8,284	5,889	45.4	752.7	90.6
RI	1,212	993	7.7	940.9	92.6
CT	5,009	3,233	24.9	663.6	92.6
TOTAL NE	66,663	12,962	100.0		
AVERAGE NE				205.7	80.4
TOTAL USA	3,618,770	246,329			
AVERAGE USA				69.5	78.1
% NE/USA	1.8	5.3			

SOURCE: U.S. Department of Commerce, Bureau of Census, Statistical Abstract of the United States, 1990.

Table No. 2

NEW ENGLAND STATES
METROPOLITAN AREAS AND CITIES WITH POPULATIONS >100,000
(1988)

NEW HAMPSHIRE
- NASHUA

MASSACHUSETTS
- LAWRENCE-HAVERHILL
- SALEM-GLOUCESTER
- BOSTON
- BROCKTON
- WORCESTER
- SPRINGFIELD
- FALL RIVER

RHODE ISLAND
- PAWTUCKET-WOONSOCKET-ATTLEBORO (MA)
- PROVIDENCE

CONNECTICUT
- BRISTOL
- HARTFORD
- NEW BRITAIN
- WATERBURY
- MIDDLETOWN
- NEW HAVEN-MERIDEN
- NEW LONDON-NORWICH
- BRIDGEPORT-MILFORD
- STAMFORD
- NORWALK
- DANBURY

SOURCE: U.S. Department of Commerce, Bureau of Census, Statistical Abstract of the United States 1990.

Table No. 3

SELECTED U.S. POPULATION DENSITIES (1988)
BY U.S. REGION AND STATE/DISTRICT

RANK	REGION	INHABITANTS PER MI^2
1	NORTHEAST	311
2	SOUTH	97
3	MIDWEST	80
4	WEST	29
RANK	STATE/DISTRICT	
1	WASHINGTON, DC	9,792
2	NEW JERSEY	1,034
3	RHODE ISLAND	941
4	CONNECTICUT	664
5	MASSACHUSETTS	753
6	MARYLAND	470
7	NEW YORK	378
8	DELAWARE	342

SOURCE: U.S. Department of Commerce, Bureau of Census, Statistical Abstract of the United States 1990.

Table No. 4

PERCENT URBANIZED POPULATION BY U.S. REGION AND STATE/DISTRICT

RANK	REGION	PERCENT OF POPULATION LIVING IN METROPOLITAN AREAS
1	NORTHEAST	88
2	WEST	84
3	MIDWEST	71
4	SOUTH	70
RANK	STATE/DISTRICT	
1	WASHINGTON, DC	100
2	NEW JERSEY	100
3	CALIFORNIA	96
4	MARYLAND	93
5	RHODE ISLAND	93
6	CONNECTICUT	93
7	NEW YORK	91
8	FLORIDA	91
9	MASSACHUSETTS	91

SOURCE: U.S. Department of Commerce, Bureau of Census, Statistical Abstract of the United States 1990.

III - THE NEW ENGLAND STATES

MAINE

The Governor of Maine's response to Assistant Secretary Page's letter is Attachment B of this report. The Governor appointed Mr. David D. Brown, Director of the Maine Emergency Management Agency (MEMA) as the State's point of contact for the New England Study.

With an estimated population of 1,205,000 inhabitants and a population density of 39 persons per square mile, Maine is New England's most sparsely populated state. Approximately 36 percent of the state's population resides in metropolitan areas compared to the New England average of 80. Maine's most populous city, Portland, had an estimated population of 75,000 inhabitants in 1990.

Water Use Vulnerability to Drought

According to the Governor, drought is not normally a concern in Maine since the state has significant annual rainfall. During extended dry periods, regions may, however, suffer crop damage, forest fires and decreased availability of water for residential, industrial, power, and waste water assimilation uses, and for fish and wildlife habitat.

Drought in Maine has its most serious negative impacts on agriculture. The potato and garden crops in Aroostook County in northern Maine are particularly vulnerable during drought. The blueberry crop in Washington County can also be vulnerable.

About 58 percent of Maine's population is on private wells. The remainder are serviced by some 3800 public water supplies under the jurisdiction of the Division of Health Engineering in the Department of Health. Except for the occasional local water shortage as a result of a water supply system deficiency, demand outstripping supply or contamination, community water supplies are relatively immune to water shortages. Portland, the state's largest city, has virtually an unlimited source of water from Sebago Lake. The southernmost part of Maine in York County is expected to continue as a high growth area. Problems of adequacy of water sources would likely occur first in southern coastal Maine.

Drought History

Based on the criterion of monthly streamflow deficiency and a period of record extending from the 1920's to the late 1980's, the U.S. Geological Survey has identified the following drought periods in Maine:

1938-43
1947-50
1955-57
1963-69
1984-88

The most severe and widespread drought of record in the State of Maine occurred during the 1963-69 period. It had a 50-60 year recurrence interval. MEMA identified the year 1960 as a drought disaster in Aroostook County.

Drought Preparedness

With respect to drought contingency planning, the Governor of Maine established a Drought Task Force in the spring of 1989 in anticipation of a drought that did not materialize. At this time, MEMA coordinated the preparation of certain documentation which has been termed a draft Drought Contingency Plan. The documentation offers guidance for drought response on an ad hoc basis.

Findings and Preliminary Conclusions

Maine disposes abundant water resources relative to the demands on them. Although the State has experienced extended dry periods in the past, it is not particularly vulnerable to drought. The State of Maine is therefore not a suitable focus for Phase II of the study of drought in New England.

The results of both the National Drought Study and its New England component could, however, benefit the state of Maine. Expected guidance on strategic water resources planning would be applicable to the high growth areas in southern coastal Maine and drought contingency and emergency planning may be useful to the Maine Emergency Management Agency and individual communities throughout the state.

NEW HAMPSHIRE

The Governor of New Hampshire's response to Assistant Secretary Page's letter is Attachment C of this report. The Governor appointed Mr. Delbert Downing, Director, N.H., Water Resource Division as the State's point of contact for the New England Study. In 1988, New Hampshire had a population of 1,085,000 persons or about 121 persons per square mile, which is nearly double the nation's average density and about one-half of New England's. Approximately 56 percent of the State's population resides in metropolitan areas compared to a New England average of 80 percent. Higher population densities are concentrated in southern New Hampshire along the Massachusetts border.

According to the New Hampshire Drought Management Plan (Page I-3), "Although New Hampshire is generally blessed with abundant rainfall which is evenly distributed throughout the year, droughts of varying magnitudes have occurred with their associated hardships to man and his activities".

Water Use Vulnerability to Drought

Water supply and wastewater assimilation are the major concerns in New Hampshire during times of drought. An estimated two-thirds of the population are on wells. The larger water supply systems generally have surface water sources, that are less susceptible to drought. The smaller public systems, whether surface or ground water supplies, and private ground water supplies have the greatest susceptibility to drought. Geographically, drought has a more severe impact in the southern and coastal parts of the state where larger numbers of people are concentrated. Wells in fractured bedrock are common in New Hampshire. Here water levels are sensitive to drought conditions and consequently draw down fairly fast.

The ability of surface waters to satisfactorily assimilate wastewater is constrained during periods of low flow due to drought. Reduced potential for assimilation leads to lower water quality thereby affecting tourism (fishing, boating, swimming, and the state's reputation for high quality of life). State officials express a growing concern for the ability of their rivers to dilute wastewaters. No systematic program has been undertaken to test rivers and streams in order to discern the seriousness of the problem.

Drought Preparedness

A task force led by the New Hampshire Department of Environmental Services has prepared the New Hampshire Drought Management Plan (The Plan) (May 1990). The Plan is comprehensive in coverage but some of the details have either not yet been worked out or have not been agreed on by all parties in the drought management process. The water suppliers have the major responsibilities for the implementation of the plan. Although drought management plans for public water supplies are required by law, these in many cases provide only minimal guidance during water emergencies. According to some officials, the independent New Hampshire character may not make it easy for local water supply companies to accept a strong state role in assuring that local plans comply with certain standards.

The Plan presents tables on the frequencies of the most severe droughts events of 3 months duration or more in southern and northern New Hampshire between 1895 and 1984. The events are identified from Palmer Hydrological Drought Indices. Table No. 5 below presents data on the most severe drought in New Hampshire between 1895 and 1984. In southern New Hampshire the drought of record occurred in 1966 over a period of 30 months and had a return period of nearly 100 years. In northern New Hampshire, the drought of record took place in 1950 over a 30 month period with a return period of nearly 100 years.

Table No. 5

MOST SEVERE DROUGHTS IN NEW HAMPSHIRE
(1895-1984)

	Drought Duration (months)	Return Period (Years)
Southern New Hampshire		
1966	30	93
1942	22	46
1911	20	31
1957	11	23
1907	10	19
Northern New Hampshire		
1950	30	93
1981	20	46
1942	11	31
1983	8	23
1965	7	19

This data may not agree with that presented in Map No. 3. The latter data uses the criteria of generalized drought conditions over a wide area, whereas the former may be limited to more localized droughts.

The Plan indicates four levels of impacts to the severity of droughts:

Level 1 Alert
Level 2 Warning
Level 3 Emergency
Level 4 Disaster

The task force could not agree on the specific hydrological limits of these stages. There was, however, general agreement that social and economic impacts should be considered with environmental impacts. The Department of Environmental Services has prepared "triggers" that would guide in the identification of the preconditions to be satisfied for each stage but again these lack consensus.

Issues of Interest

The New Hampshire staff proposed that the following issues be addressed in the National Study:

-the use of existing flood control structures for streamflow augmentation,

- the role of state government in drought contingency planning,

- how to better sensitize people to drought,

- how to prioritize competing uses for water, for example, water used for snowmaking in New England can significantly impact impoundments,

- research needed on yields and areas of influence for wells in fractured bedrock.

Findings and Preliminary Conclusions

Although droughts of varying degrees of severity have occurred in New Hampshire, its water resources generally are abundant and evenly distributed throughout the year relative to the demand for these resources. New Hampshire would therefore not be the optional region to focus study efforts during Phase II of the New England Drought Study.

The State of New Hampshire could, however, both contribute to the New England Drought Study and benefit from it. The modeling of strategic water resources planning to be developed during Phase II may be applicable to the high growth areas in the southern part of the state or to communities where demand is approaching the safe yield of their water supplies. In addition, the New Hampshire Drought Management Plan will be examined and components incorporated, as appropriate, into the drought contingency and emergency planning approaches to be developed as part of the study.

VERMONT

The Governor of Vermont's response to Assistant Secretary Page's letter is Attachment D of this report. The Governor appointed Mr. George Lowe, Director, Department of Public Safety in the Emergency Management Division as the State's point of contact for the New England Drought Study.

Vermont can be characterized as a relatively water rich state due to its abundant water resources relative to the demands put on them. With an estimated population in 1988 of 557,000 inhabitants, Vermont is second only to Maine in the sparsity of its population density of 60 inhabitants per square mile, compared to a New England average of 206. Only seven of Vermont's cities and towns have populations of more than ten thousand inhabitants in 1990: Burlington, 39,127; Rutland, 18,230; Essex, 16,498; Bennington, 16,451; Colchester, 14,731; South Burlington, 12,809 and Brattleboro, 12,241. Twenty-three percent of Vermont's population resides in metropolitan areas compared to New England and national averages respectively of 80 and 78 percent.

Water Use Vulnerability to Drought

Although there have been periods of persistent dryness, no serious drought has visited Vermont since the drought of the 1960's. Water shortages in Vermont have primarily affected residential and agricultural, including livestock, usage. The 1960's drought prompted the systematic upgrading of public water supply systems where shortages existed due to system deficiencies. The Jericho-Underhill area had been on a moratorium, with respect to new connections to the system, but a new source has been found. Waterbury has drilled more wells in order to alleviate its water shortage problem. Today, dug wells and spring-fed sources and also drilled wells are the most vulnerable to drought. Franklin and Addison Counties in northwestern and western Vermont have experienced water supply emergencies for livestock and agriculture. Water was pumped or trucked as farm ponds and watering holes dried up. Meanwhile, farm water supplies have been developed and improved.

Vermont's Agency of Development and Community Affairs has issued a publication entitled, Population Comparison By Town (1980 - 1990) which is based on the Bureau of Census data. The report indicates that population growth trends are concentrating in suburban and rural communities, where inhabitants tend to obtain their water from private wells. Of the twenty-two communities in Vermont with populations exceeding 5,000 people in 1990, only five of them have equaled or exceeded the state's 10 percent growth rate for the period. Four of these cities/towns, in fact, experienced population losses during the decade.

Drought Preparedness

Drought Response is on an ad hoc basis. Vermont has not prepared a drought contingency plan. The state, however, in cooperation with the U.S. Geological Survey, monitors groundwater levels and notes departures from the long term median values. Given the large number of Vermonters on private wells, groundwater levels are particularly important indicators of the vulnerability of the population to drought. Significant downward trends, that could possibly lead to drought conditions, are reported to the Emergency Management Division. Otherwise potential water shortages are reported by individuals, communities, etc. If these are confirmed then the Governor would convene a task force to monitor conditions and could eventually exercise emergency powers to deal with the water shortage.

Persistent dry periods prompted creation of Water Shortage Task Forces in 1980 and 1988. The 1980 Task Force developed a series of pamphlets dealing with ways for farmers and well owners to better control water and in some cases prevent water shortages. The 1988 Task Force anticipated a drought which never materialized because of the onset of adequate rainfall.

Issues of Interest

The Vermont staff indicated that they would like to see the following issues addressed in the National Study:

- How other states monitor ground water levels,

- How to control spilling from wells,

- The actions of other states on the water table in Vermont.

Findings and Preliminary Conclusions

Although there have been periods of persistent drought, water resources in Vermont are relatively abundant compared to current and projected water use. Sophisticated drought contingency plans have, therefore not been developed. The State of Vermont would not be an appropriate candidate for concentrating a drought study effort in New England during Phase II.

The State of Vermont would, however, benefit from the drought contingency and emergency planning models to be developed in both the National Drought Study and its New England component.

MASSACHUSETTS

Assistant Secretary Page's letter to the Governor of Massachusetts in March 1990 was followed by contacts with the Director of the Massachusetts Water Resource Commission, and the Departments of Environmental Management (DEM), and Environmental Protection (DEP) and the Massachusetts Water Resources Authority (MWRA).

With an estimated population in 1988 of 5,889,000 inhabitants, Massachusetts is New England's most populous state. Its population density of 753 persons per square mile ranks Massachusetts second to Rhode Island (941 persons per square mile) in New England. Approximately 93 percent of Massachusetts' population resides in metropolitan areas compared to New England and national averages of 80 and 78. Massachusetts can be characterized as having a highly urbanized and relatively densely settled population.

Water Use Vulnerability to Drought

Discussions with the Massachusetts Departments of Environmental Management (DEM) and Environmental Protection (DEP) have led to the conclusion that the water use most vulnerable to drought in Massachusetts is that of municipal and industrial (M&I) water and more specifically, the Massachusetts Water Resources Authority/Metropolitan District Commission (MWRA/MDC) System. Both the MWRA/MDC and the DEP have major responsibilities with respect to the management of municipal and industrial water supplies and conveyance systems in Massachusetts. Map No. 3 indicates that the Connecticut River Basin in New Hampshire and Massachusetts has experienced the longest historical severe drought durations of 24 to 36 months in New England. This portion of the basin is the principal source of water supply for the MWRA/MDC Water Supply.

Department of Environmental Protection (DEP)

The DEP administers Federal and state drinking water standards and provides guidance to communities and water supply agencies to ensure safe and adequate water supplies through its Division of Water Supply (DES). Through the powers vested in it from the Massachusetts Water Management Act, the DEP regulates withdrawals of surface and groundwater water in the Commonwealth and is responsible for the issuance of declarations of water emergencies including water shortage emergencies upon the request of the water suppliers. In addition, DEP is authorized to require water suppliers to remedy the causes of water supply shortages including improved water resources planning, conservation, and water supply and demand management, and the construction of system improvements or temporary restrictions.[1/]

1/ Massachusetts, Department of Environmental Protection, DEP Procedures for Water Emergencies, February 10, 1989.

The Massachusetts Water Resources Authority/Metropolitan District Commission (MWRA/MDC)

a. History

The following has been abstracted from the document, MWRA Long Range Water Supply Program (January 24, 1990), in order to illustrate the process of development of the water supply system for the greater Boston area and the evolution of the environments in which decisions have been made.

"Since 1652 when the first public water supply was constructed in Boston, water supply planners in our region have periodically faced the problem of ensuring a sufficient supply of clean drinking water in the face of demand growth and degradation of current sources. In each instance, they chose to look west, outside the city, for larger supplies of cleaner water: in 1795 to Jamaica Pond, in 1848 to Lake Cochituate, in the 1870's to the Framingham and Sudbury Reservoirs, in 1895 to Wachusett Reservoir and in the 1930's to the Ware River and Quabbin Reservoir. When demand began to exceed the available supply in the 1970's, water supply planners looked west again to the Connecticut River. This time, however, the process was resisted. Whereas in the past, growth of demand seemed natural, and fouling of more urban supplies inevitable, those assumptions were now in question. In the past, substantial alteration of the natural and man-made environment in one location for the "greater good" of the urban dwellers was considered more than reasonable. Now, a new consciousness of the long-term destruction of the environment called the traditional trade-offs into question. The stage was set for a protracted technical and environmental review of our water supply situation, and a change in the type of solution chosen."

Water resources development in Massachusetts in the 1980's was characterized by continued growth in demand for M&I water, less than normal rainfall, new Federal regulations (Safe Drinking Water Act, Wetlands Legislation, etc.) and a growing movement to resist the development of new supplies. The 1986 amendments to the Safe Drinking Water Act have prescribed more stringent water quality standards necessitating the consideration of improved watershed protection or water treatment for water from presently untreated sources such as Quabbin Reservoir.

In response to the evolving water resources environment, the Massachusetts Water Resources Authority (MWRA) was established in 1985 as an independent water authority. In some respects, the MWRA is a successor to the Metropolitan District Commission (MDC) which continues to manage the watersheds and reservoirs in the MWRA service area. The MDC did not have the independence of action enjoyed by the MWRA. Under the MDC, the original design of the Quabbin-Wachusett system included adding parallel aqueducts in order to ensure redundancy in the system. See Figure 2. However, the MDC requested but had not received funding from the legislature to implement these works. The creation of the MWRA/MDC as a financially independent system would put the issue of redundancy within the purview of the current system managers.

The MWRA/MDC System's main objectives include the cleanup of Boston Harbor, improvements to the aging water and sewerage infrastructures, provision of pure and adequate drinking water and conservation.[1/]

Today the MWRA/MDC system has responsibility for wholesaling municipal and industrial water to 46 cities and towns in Massachusetts or approximately 2.5 million people which constitutes about 45% of the population of Massachusetts. In addition, the agency collects and treats wastewater for communities in the greater Boston area. Beginning with the most westerly source, water is obtained principally from the Connecticut River Basin via the Quabbin Reservoir located some 60 miles west of Boston and the Ware River Intake. The third source is the Wachusett Reservoir located in the Merrimack River Basin. The Sudbury Reservoir, also in the Merrimack Basin, is currently not in use because of its poor quality. The Connecticut Basin is shared by the states of New Hampshire, Vermont, Massachusetts, and Connecticut and the Merrimack by New Hampshire and Massachusetts. Although this study considers only the MWRA/MDC water supply functions, economies can be realized by combining the dual functions of water supply and wastewater management. More efficient water use, for example, can reduce both the loading on the wastewater system and the associated capital, and recurrent (energy, treatment, etc.) costs.

b. Safe Yield and Demand for Water

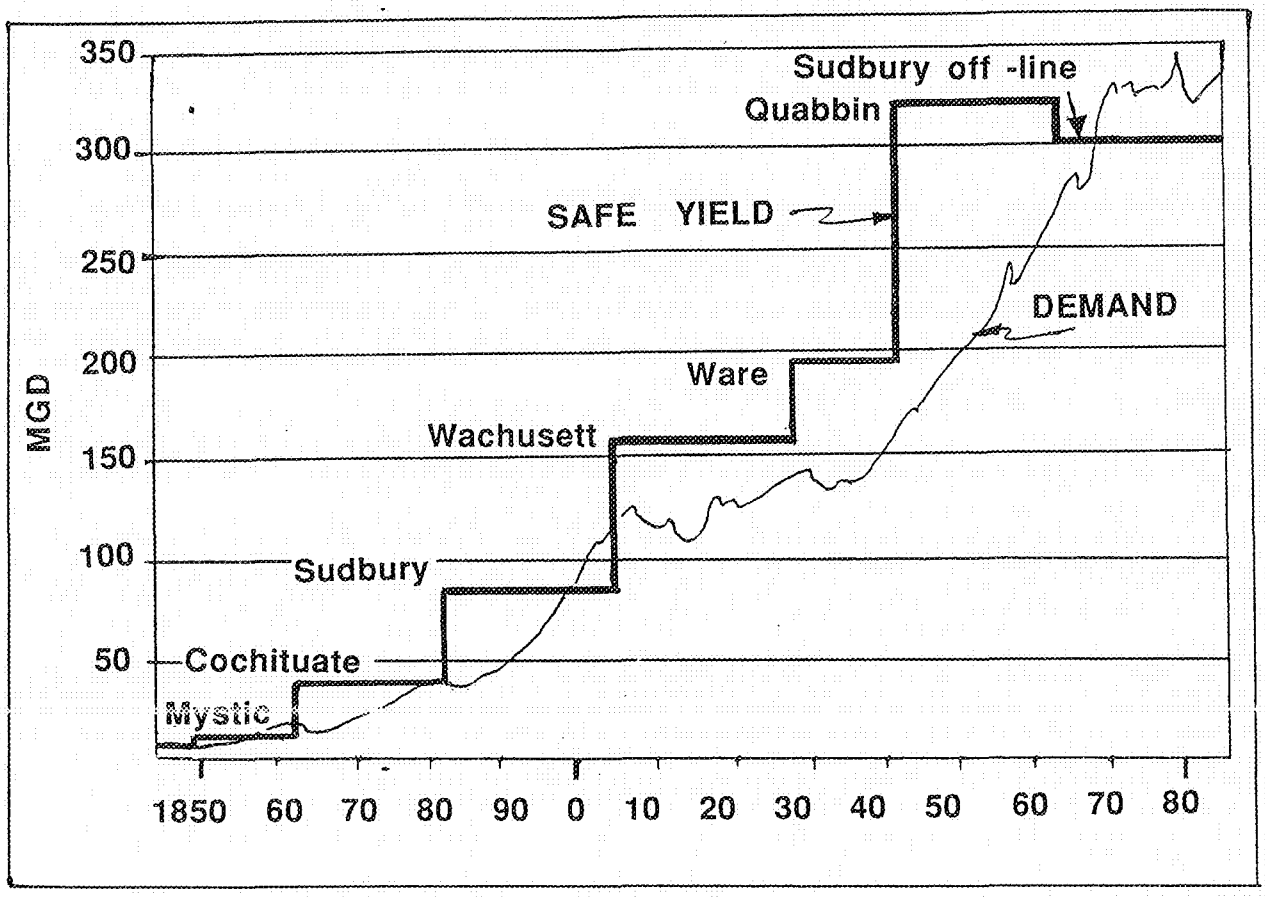
The current safe yield of the MWRA/MDC system is based on a very sophisticated model which takes into account the availability of over year storage at the principal storage component in the system, Quabbin Reservoir. Figure No. 1 presents the historical safe yield of the Greater Boston water supply system between 1848 and 1985. The demand for water had exceeded the 300 million gallons per day (MGD) safe yield for the period since the 1960's. However, supply and demand management measures undertaken by the MWRA since 1988 have reduced demand below the safe yield.

Also illustrated is the aging of the MWRA/MDC infrastructure. The most recent element is the Quabbin Reservoir system which is more than 50 years old and which accounts for a high proportion of the total system's safe yield capacity. Other components of the system are over 100-years old. The age of the Quabbin system in addition to the lack of redundancy and aging of the transmission system puts the water supply system at even greater risk of failure and disruption. See Figure 2 for a plan of the MWRA/MDC water system.

1/ MWRA/MDC - Draft Drought Management Plan P3-1.

Figure No. 1

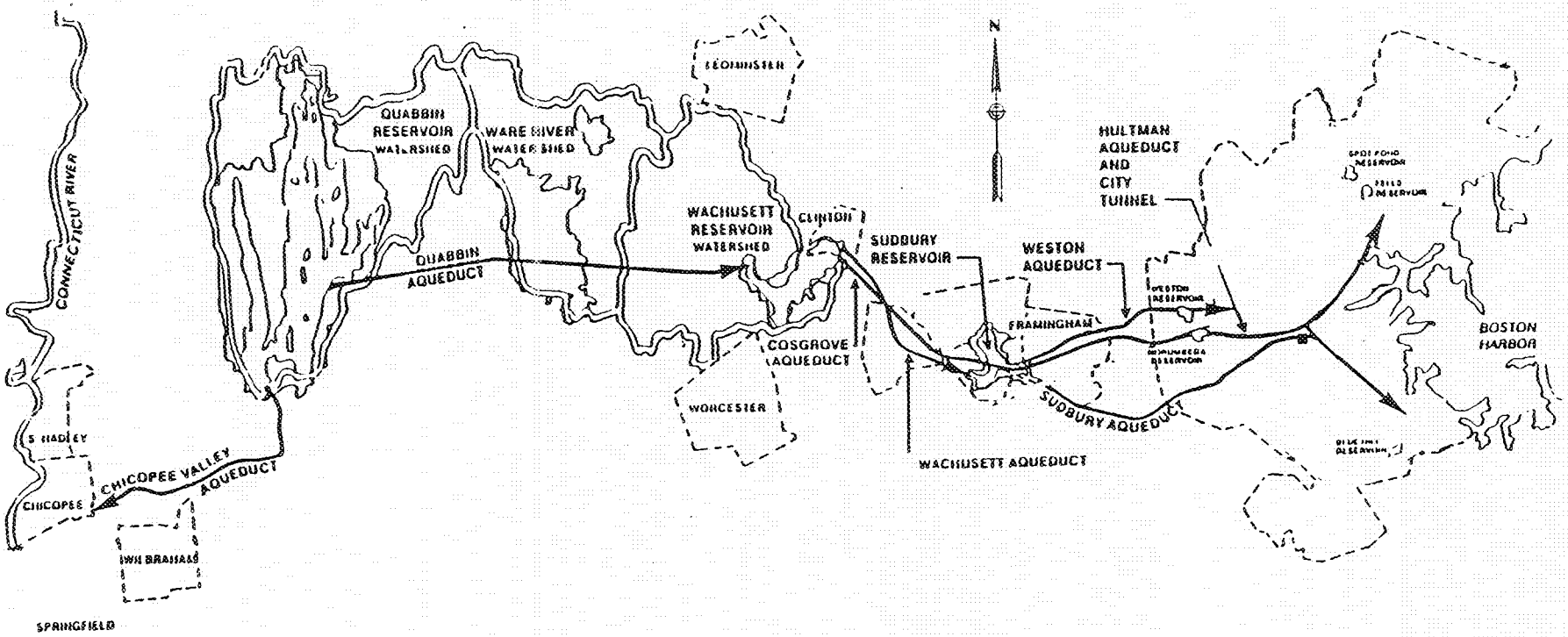
METROPOLITAN BOSTON, MASS.
WATER SUPPLY AND DEMAND 1848-1985



Source: Massachusetts Water Resources Authority, MWRA Long Range Water Supply Program, January 1990, p.7

FIGURE NO. 2

GENERAL PLAN OF MWRA/MDC WATER SYSTEM



SOURCE: MWRA/MDC - Draft Drought Management Plan 1989, p.3-3

c. Water Shortages

The MWRA has provided the following chronology of water shortages between 1965 and 1989.

- o On August 11, 1965 the MDC issued restrictions once the Quabbin Reservoir reached 510.28 feet or 65.37% of capacity.
- o The historic low level at the Quabbin was 44.% full on May 5, 1967.
- o In May, 1985 Commissioner William Geary issued a "Drought Watch" for the Quabbin/Wachusett system.
- o The Quabbin Reservoir began 1989 at 69.4% of capacity, compared to the 40 year average capacity for January 1st of 81%.
- o As of the press conference on February 16, 1989 the water level at Quabbin was 68.3% of capacity.
- o In the 1960's, water demand (use) was 280 million gallons per day compared to 324 mgd used in 1988.

d. Long Range Water Supply (LRWS) Planning[1/]

The LRWS planning process was initiated by MWRA's predecessor agency, the MDC, in 1977 to meet the metropolitan Boston area's water needs up to the year 2020. Earlier planning work included the Connecticut River estuarine and Northfield tunnel route environmental studies conducted for the MDC by the Institute for Man and the Environment at the University of Massachusetts; the U.S. Army Corps of Engineers Northeastern United States Water Supply (NEWS) Study, 1969-72; the New England River Basin Commission's Southeastern New England (SENE) Study, 1977; and the Massachusetts Water Supply Policy prepared by the Executive Office of Environmental Affairs and adopted by the Massachusetts Water Resources Commission in 1978. After extensive analysis, preparation and review, the MWRA's Board of Directors on November 12, 1986 adopted the MWRA Long Range Water Supply Policy. THE POLICY RESTED ON THE DECISION THAT AUGMENTATION OF THE WATER SUPPLY BY THE DIVERSION OF WATER FROM ONE OR MORE RIVERS WAS ONE OF LAST RESORT. The Policy emphasized water supply and demand management in lieu developing new supplies until after December 1989.

The MWRA and several other communities, not part of its system, have responded by undertaking a series of measures to obviate the need for new supplies. These measures seek to effectively increase the supply of water delivered to consumers without resort to new sources and to reduce consumer demand for water. For example the MWRA is engaged in a program for

- water supply management

  - . watershed protection
  - . leak detection and repair of MWRA transmission lines
  - . repair of malfunctioning wholesale water meters
  - . Assessment of developing local water supplies in present or potential MWRA/MDC served communities

1/ MWRA-MDC-MWRA Long Range Water Supply Study and Environmental Impact Report - 2020 Phase II, October 1990.

- water demand management

    . leak detection and repair distribution systems
    . repair water meters
    . domestic conservation
        .. domestic device retrofit (low flow shower heads, faucet aerators, displacement devices in toilet tanks)
        .. public and nonprofit housing retrofit
        .. changes in state plumbing code to replace 3.5 gallon with 1.6 gallon toilet
    . non-domestic conservation
        .. water audits for industries and institutions
    . water conservation information
        .. school information program
    . pricing
        .. retail rates technical assistance

These programs have been very successful. During the first two years of their implementation in 1988 and 1989, water use in the MWRA system dropped below 300 mgd for the first time in in 20 years. An, as yet, undetermined amount of this decrease is attributable to the supply and demand management programs in the form of leak detection and repair and non-domestic conservation.

Drought Preparedness

The MWRA/MDC has prepared a draft Drought Management Plan. The plan is principally concerned with the monitoring of water levels at Quabbin Reservoir. The different stages of drought severity (normal, below normal, drought warning, and drought emergency stages 1, 2, and 3) are keyed into reservoir levels. Appropriate system responses are prescribed for each phase. The establishment of a system wide drought management plan involving the individual communities in the MWRA/MDC system has also been preliminarily addressed. According to DEP, the communities of Easton, Wellesley, Bedford and Marblehead have prepared among the most effective individual drought management plans in the state.

The MWRA/MDC sees a need to improve the emergency stage activities of drought response. In particular, there is a need to standardize the response procedures among the system communities.

Issues of Interest

DEP and MWRA/MDC staff have expressed an interest in pursuing the following issues during Phase II:

- analyses to determine the most effective demand management activities,
- incentives to encourage water suppliers to adopt drought management plans,
- during a severe drought, the most effective ways of influencing consumer behavior ,

- during drought emergencies, there is a need to standardize the response procedures among system communities
- the need to develop and/or upgrade analytical decision-making tools or triggers to identify when actions should be taken to facilitate water resources management and avert water supply problems, and
- the need to update the forecast of future water supply demands based on current socioeconomic data.

Findings and Preliminary Conclusions

The MWRA/MDC System for providing potable water for the metropolitan Boston area and other selected communities is an example of a municipal and industrial water supply agency that has been highly vulnerable to drought, and has initiated innovative strategic, contingency and emergency planning measures to anticipate and deal with water shortages. It has also registered a commitment to participate in Phase II of the present study.

The MWRA/MDC system is particularly vulnerable to drought on climatological grounds. Its principal sources of water are drawn outside the basin from the Connecticut and Merrimack River Basin where the longest duration severe droughts in New England on record have occurred i.e., 24 to 36 months. In addition the area has not experienced a serious drought since the 1960's.

With respect to the system itself, portions of the infrastructure are old and in need of replacement and major elements such as aqueducts lack redundancy. However, MWRA's redundancy planning efforts have resulted in immediate plans to provide redundancy for the Hultman Aqueduct with the rehabilitation of the Sudbury Aqueduct at a cost estimated at $225 million. Future planning is directed at the improvement to the Weston Aqueduct and Wachusett By-Pass Tunnel at a cost estimated between $400-430 million. The MWRA/MDC had been operating above its safe yield of 300 mgd since the mid-1970's until the adoption of effective water supply and demand management measures in the late 1980's.

In terms of vulnerability due to institutional considerations, the Massachusetts legislature's creation of the MWRA/MDC in 1985 as an independent and financially autonomous agency has made it possible for the agency to raise its own revenues and to design, operate the system in accordance with sound managerial principles. The occasional news reports that the legislature may preempt MWRA/MDC income for use elsewhere in the Commonwealth in order to bring into balance its budget instills the risk of returning to an earlier situation where needed investments to assure redundancy were not made thereby increasing the system's vulnerability to water shortages.

In addition Federal mandates such as the Safe Drinking Water Act, which has essentially redefined the concept of potable water, and also wetlands legislation as well as grassroots and interstate resistance, may effectively reduce present water supply or make it more difficult and/or more costly to develop new sources. In Massachusetts, the Water Management Act and the Interbasin Transfer Act can limit the volume of water available for supply.

Faced with the potential shrinking of existing water supplies and difficulties of developing new ones, the MWRA/MDC has adopted strategic planning strategies which permit it to wring more use out of existing supplies through innovative water supply and demand management measures and to anticipate water shortages, including drought, with improved contingency and emergency planning. The MWRA/MDC experience may be selectively applicable to urbanized regions of the United States which are laboring under political, regulatory, technical, legal, financial, etc., constraints in planning to meet increased demands for municipal and industrial water supply under normal conditions and during water shortages.

RHODE ISLAND

The Governor of Rhode Island's response to Assistant Secretary Page's letter is Attachment E of this report. The Governor appointed Mr. Robert K. Griffith, Jr., of the Office of Strategic Planning in the Rhode Island Division of Planning, who also serves as Executive Director of the Water Resources Coordinating Council, as the State's point of contact for the New England Study.

With an estimated population in 1988 of 993,000, the nation's smallest state ranks third after Washington, DC and New Jersey in population density with 941 persons per square mile. Along with the State of Connecticut, Rhode Island is among the most highly urbanized State in New England with nearly 93 percent of the population residing in Metropolitan areas. Major metropolitan areas are Providence and Pawtucket/Woonsocket.

Water Use Vulnerability to Drought

A schematic of the State of Rhode Island's organization for the management of water resources is presented in Figure No. 3. Responsibilities for water resources are widely dispersed among federal, state, regional and local agencies. Four regional and ten local systems ensure municipal and industrial water for the State's population. None of the regional or local systems are operated by the State of Rhode Island.

Among the various off-stream and in-stream water users, the State's municipal and industrial water supplies are the most vulnerable to water shortages due to weather conditions and other emergencies. Among these, the Scituate Reservoir system, which is operated by the Providence Water Supply Board to serve the metropolitan Providence area (the communities of Providence, Cranston, Warwick, East Providence, East Smithfield, Greenville, Lincoln, Smithfield, and the Kent County Water Authority), is at greatest risk. The Board is an agency of the City of Providence and supplies approximately two-thirds of the State's potable water. The southeastern part of the State and Aquidneck Island (Newport, Middletown and Portsmouth) are also particularly vulnerable to drought.

The state has created the Water Resources Coordinating Council (WRCC) to advise the Governor on all matters relating to water policies. The WRCC has sponsored the report entitled Water Supply Analysis for the State of Rhode Island (October 1990) and undertaken by a team of consultants led by Arthur D. Little, Inc. The report determined current potable water use and projected needs over the next twenty years. The report concluded that the safe yield of Rhode Island's developed public water supplies is estimated between 150 and 160 million gallons per day (MGD). Based on present trends, water use by the year 2010 is projected to be about 132 MGD, but water availability does not always match the location of the users. In the absence of new water supply and demand initiatives, significant shortfalls could occur in the regions served by the Scituate Reservoir and in the southeastern part of the State, which is dependent on groundwater and in the Aquidneck Island region.

In addition, the Scituate Reservoir System lacks redundancy. The rupture of a major system component, for which there is no adequate alternative to prevent failure of the system, could put the Scituate Reservoir's System at risk for serving two-thirds of the State's population. The State's attempt to address the issues of redundancy and safe yield has been thwarted by Federal mandates. The drought of record in Rhode Island is that of the 1960's. In response to this drought, efforts were made to augment the supply of water to the greater Providence area. In this respect, the Big River Project has been studied by the New England Division of the Corps of Engineers and the State of Rhode Island since 1978 for water supply augmentation of the metropolitan Providence area. The U.S. Environmental Protection Agency has vetoed the proposal because of the potential negative impacts on wetlands. Current efforts are devoted to other Big River water supply augmentation options and measures to wring more water use from current supplies.

Subsequently in 1991, the State's General Assembly passed the Water Supply Management Act. The Act, in its present form, requires each community in the State to prepare, among others, water supply management plans, including demand management measures, and emergency management to deal with loss of water supply due to natural and human made causes. The water supply management plans look very much like the conservation measures undertaken by the Massachusetts Water Resources Authority when faced with the mandate not to develop new supplies except as a last resort.

Drought Preparedness

The State of Rhode Island manages drought on an ad hoc basis. In the event of a serious water shortage, the Governor would declare an emergency and measures to deal with the drought would be taken by the local water supply companies. Several Rhode Island communities have already prepared drought contingency plans. The application of the provisions of the Water Management Act would improve water management during drought in Rhode Island.

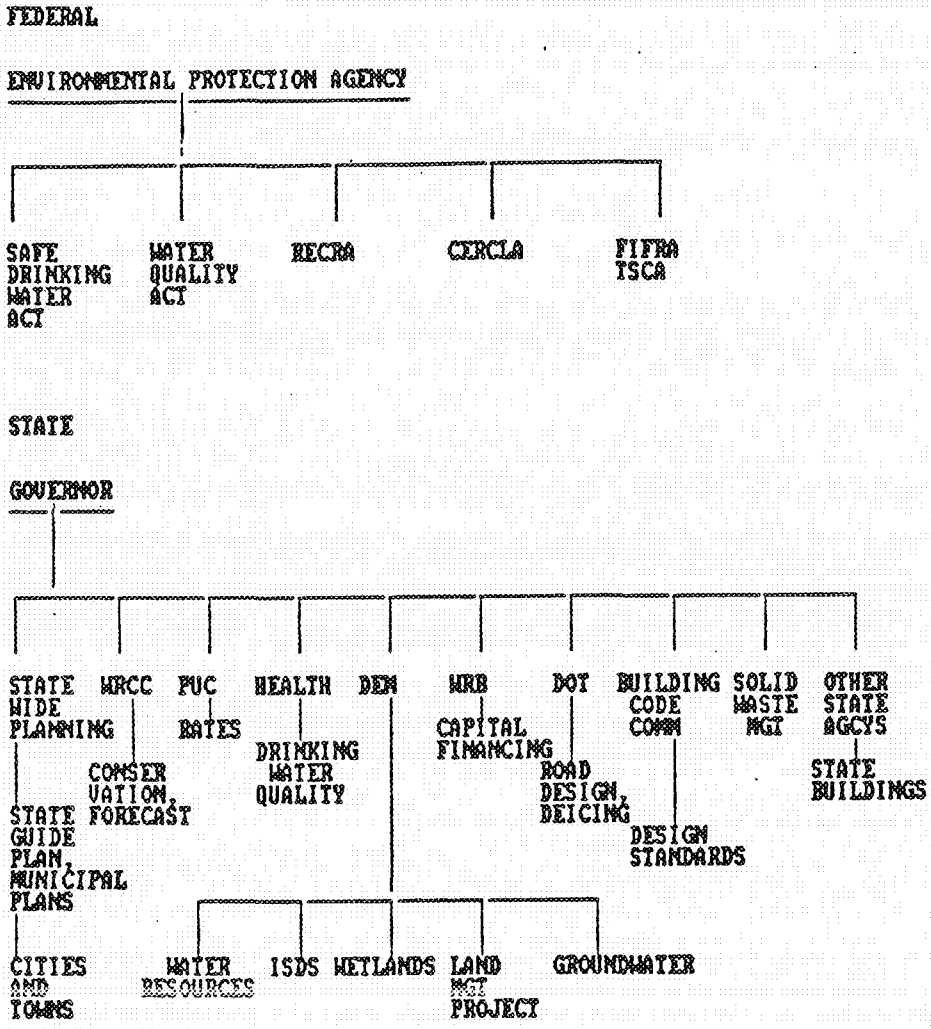
Issues of Interest

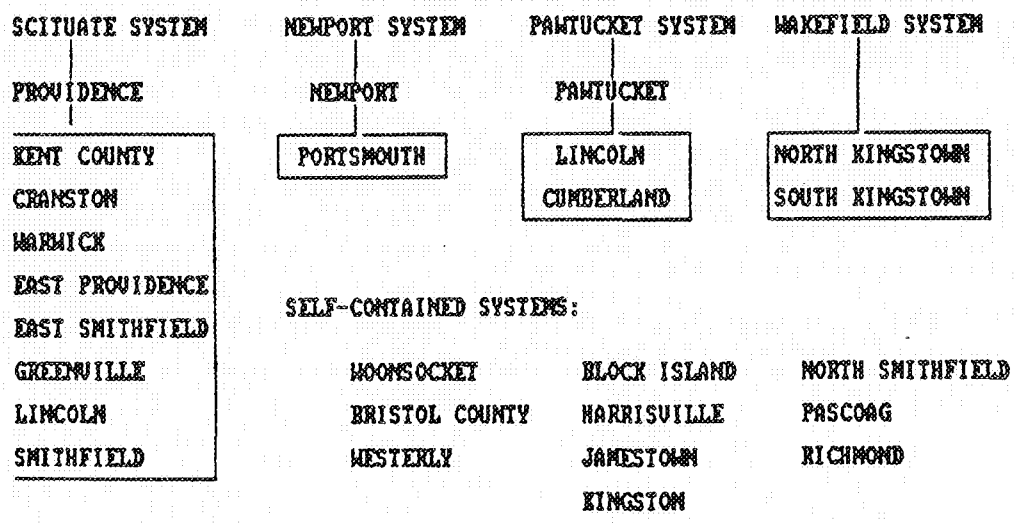
State planning staff recommended that the following products of the National Study of Water Management During Drought be:

- drought contingency procedures for different regional models, and
- a software package for hydrological monitoring.

FIGURE NO. 3

RHODE ISLAND'S PRESENT WATER RESOURCES MANAGEMENT SYSTEM - 1991





SOURCE: Office of Strategic Planning, Providence, R.I.

Findings and Preliminary Conclusions

With respect to water resources management, there are similarities between Rhode Island and the other two densely populated and highly urbanized states in New England: Massachusetts and Connecticut. Like Massachusetts, Rhode Island has been thwarted in its efforts to augment its supply of municipal and industrial water and has turned to supply and demand management measures in order to wring more water use out of existing systems. Similarly, the State of Connecticut has adopted measures to use its water resources more efficiently in order to obviate the development of new water sources. An analysis of the water supply and demand measures undertaken by the Massachusetts Water Resources Authority, in particular, and possibly those of the State of Connecticut, could provide the State of Rhode Island with information on what measures work best in maximizing water use from existing sources.

CONNECTICUT

During Phase I of the present study, the State of Connecticut was in a period of budgetary crisis characterized in the State Agencies by staff reductions and increased work loads. It was not possible for the staff to provide the information necessary to give a complete picture of the State's vulnerability to drought.

The former Governor of Connecticut's response to Assistant Secretary Page's letter is Attachment F of this report. At that time, he designated the Under Secretary for Comprehensive Planning in the Office of Policy and Management as the State's point of contact for the study.

With an estimated population in 1988 of 3,233,000, the State of Connecticut is home for approximately one-quarter of New England's population. The State ranks fourth nationwide in population density after Washington, DC, New Jersey and Rhode Island with 664 persons per square. It ranks with Rhode Island as the most urbanized portion of New England and among the most urbanized states nationally with about 93 percent of the inhabitants living in metropolitan areas.

Vulnerability to Drought

State of Connecticut officials indicate that a catastrophic event in the form of a water supply system failure or a chemical spill, for example, are more likely to cause water shortages in the State than hydrological droughts. Nevertheless, municipal and industrial water supplies, and particularly those in the southeastern part of the state, and waste water assimilation are the two most vulnerable water uses to drought.

Water Resources Management

a. Water Resources Planning

It appears that the State of Connecticut has initiated the required legislative and policy actions for effective strategic, drought contingency and emergency water resources planning through the coordinated activities of the state's agencies that deal with water resources agencies, namely, the Departments of Environmental Protection (DEP), Health Services (DOHS) and Public Utility Control (DPUC) and by the Office of Policy and Management. Connecticut staff claim to be on the cutting edge of strategic planning, and water supply and demand management. Connecticut has the first statewide demand management retrofit program in the United States. All water supplies, serving more than one thousand people or 250 or more customers, are scheduled in the next couple of years to offer retrofitting to customers in their service areas. A publication entitled, Step by Step Design of a Residential Retrofit Program (February 1991) by Denise M. Ruzicka offers guidance for the program.

b. Drought Preparedness

Drought contingency planning has been initiated by Connecticut's Department of Health Services which has lead responsibility for the State's municipal and industrial water suppliers. In the event of the governor's declaration of a water supply emergency in part or in the entire State of Connecticut or otherwise according to law, the State of Connecticut would initiate a set of procedures in order to ensure a constant supply of water to drought affected communities. Guidance for these procedures is provided in the Water Companies Planning Guidance for Emergency Contingency Plans (December 1990) prepared by the DEP, DOHS and DPUC and the Offices of Consumer Council and Policy Management. These regulations require water companies supplying water to one thousand or more persons or 250 or more consumers to prepare a water supply plan. One component of the plan is "contingency procedures for public drinking water supply emergencies including emergencies concerning the contamination of water, the failure of a water supply system or the shortage of water" (page 7). Communities are expected to prepare emergency contingency plans according to the following indicators of the onset of different levels of water shortage severity and appropriate responses tailored to these indicators.

Alert
Advisory
Emergency
    Phase I
    Phase II
    Phase III

State agencies are currently reviewing water supply plans, which include water conservation and emergency contingency plans, submitted by the individual water companies.

Findings and Preliminary Conclusions

Based on limited discussions with State of Connecticut Staff (OHM, DOHS, DEP and DPUC), it appears that the State of Connecticut has initiated legislative, policy, and programming actions to anticipate and respond to drought. All of Connecticut's water supply companies, serving more than one thousand people or 250 customers or more, are preparing water supply master plans including emergency contingency plans. Water demand management practices in Connecticut are among the most advanced in New England and possibly nationwide.

Unfortunately Connecticut staff were not interested in providing all of the required information for this study in order to realize an adequate assessment of the State's vulnerability to drought and of the value of its experience in drought management to other parts of the United States. Consequently, the State of Connecticut would not be a major focus of Phase II efforts of the New England Drought Study. However, during Phase II, state officials will be recontacted to determine to what extent the State of Connecticut's water resources planning experience can both contribute to the National Drought Study and its New England component and profit from them.

IV - SUMMARY OF FINDINGS AND CONCLUSIONS

Although there have been periods of persistent dryness, no serious drought, or otherwise water shortage, has visited New England since the 1960's. However during periods of low rainfall there are regions in all of the six New England states that are vulnerable to drought. The uses at highest risk are municipal and industrial water supply, crop and livestock production, and wastewater assimilation. Because of the large number of people impacted by water shortages or system failures, municipal and industrial supply throughout New England, and particularly those in the highly urbanized areas of Massachusetts, Rhode Island and Connecticut, is the use most vulnerable to water shortages in New England.

One initial response to the 1960's drought has been the improvement of water supply delivery systems to rural and urban populations and to crops and livestock. Later comprehensive planning studies to develop new sources of water were completed in order to satisfy increasing demand for water and incidentally to reduce the communities' vulnerability to potential water shortages. Attempts to implement some of the recommendations of these studies to develop new sources of water, particularly in southern New England (Massachusetts, Rhode Island, and Connecticut), where over three-quarters of the regional population principally resides in urbanized communities, has met with resistance. This resistance has pitted rural dwellers, other states sharing a common water resource, environmental groups and federal, state and local enforcement agencies against the development of new municipal and industrial water supplies. Meanwhile changes in federal laws such as the Safe Drinking Water Act and wetlands legislation have more rigorously redefined potable water or otherwise removed certain water resources from future development or require additional investment for their development.

A more recent response to potential shortfalls in water supply for urban areas has been decisions on the part of several New England States to apply water supply and demand management measures. On the one hand, these practises would wring more water out of the existing systems, and on the other, reduce demand through water conservation thereby obviating the need to develop new sources. The states of Massachusetts, Rhode Island and Connecticut are each in different stages of implementing the required legislative, policy, and institutional foundations for their supply and demand management programs. In addition the Massachusetts MWRA\MDC, which services the greater Boston area, has incorporated its programs into a strategic, drought contingency and emergency planning framework that not only very effectively addresses the objectives of the National Drought Study, but would be relevant to other urban areas in New England or elsewhere in the United States. The MWRA/MDC's principal source of water is derived from the part of the Connecticut River Basin which has historically experienced the longest period of severe drought on record, and is therefore particularly vulnerable to drought. The MWRA has indicated to NED its willingness to serve as a case study for Phase II of the New England Drought Study. See Attachment G.

Subsequent discussions with MWRA staff have led to an agreement, in principle, on the following two topics for Phase II of the study:

- in response to mandates to provide for new water demands without developing new supplies, to describe, analyze, enhance and model the MWRA/MDC strategic, drought contingency, and emergency water resources planning, including supply and demand management, experience, and to identify water systems where the model may be applied.

- to assist the MWRA/MDC in extending its current planning experience by developing techniques to enhance its decision-making process and particularly as related to water resources planning while taking into account risk and uncertainty. A trigger planning process would be developed for ensuring that future water supplies are adequate to meet projected demand by identifying early actions that should be taken in order to avoid water supply problems.

In conclusion, the proposed case study of the MWRA\MDC would showcase its experience in drought contingency and emergency planning within the framework of it strategic water resources planning. Of particular national interest are MWRA\MDC efforts to enhance the quantity of water delivered to communities in its service area through the use of supply management measures and to reduce the demand for water through demand management techniques. Another focus would be to work with MWRA/MDC staff to develop trigger planning techniques to identify, schedule and implement decisions and activities that are prerequisites to ensuring that future water supply is adequate in quantity, quality, and reliability to meet demand.

The MWRA/MDC experience may be selectively applicable to other urban areas in New England and elsewhere in the United States, and particularly those in the northeast that have not experienced a serious drought for some time and/are approaching the safe yield of their water systems. This experience may be of particular relevance to those cities with water systems that are old, lacking redundancy,and needing capital improvements and which are laboring under political, regulatory, technical, legal, etc. constraints in planning to meet increased demands for municipal and industrial water supply.

V - RECOMMENDATIONS

It is recommended that the Massachusetts Water Resources Authority/ Metropolitan District Commission (MWRA/MDC) water supply system, serving approximately 2.5 million people in 46 communities primarily in the metropolitan Boston area, be the object of the case study for Phase II of the Study of the Vulnerability of New England to Drought. The study would model the MWRA/MDC experience in drought contingency and emergency planning within the framework of strategic water resources planning with an emphasis on water supply and demand management. Another focus would be to develop a trigger planning decision-making model for the MWRA/MDC water supply system for ensuring that short, medium, and long range water needs are met with sources of water that are adequate in quantity, quality, and reliability.

It is further recommended that all of the New England states be associated with Phase II of the New England Drought Study. The nature of the association would be the object of discussions between the New England Division of the Corps of Engineers and individual states. At a minimum each state would benefit from the results of the study for application, as appropriate, to water supply entities within the state.

Since the states of Connecticut and Rhode Island have been under similar constraints as the MWRA/MDC to develop new sources of water supply and have adopted similar approaches to enhancing the quantity of water delivered from existing sources and to modulating demand through conservation, it is further recommended that they be closely associated with Phase II, in order to both enrich and profit from the study.

ATTACHMENTS

An Outline for the New England Drought Vulnerability Study
the FY91 New England Division Study for the
National Study of Water Management During Drought

The purpose of this work is to report generally on the vulnerability to drought in the New England states, and to determine which region in New England should be the subject of additional work under the National Study of Water Management During Drought in Fiscal Years 92 and 93.

That determination will be based on three factors: the degree to which a region is vulnerable to drought; (2) the willingness of regional water management agencies to cooperate in such work; and (3) the value of such work to completing a national assessment of drought preparedness. The report will be based on information found in existing reports, obtained through the states and regional agencies during the course of this study, and provided by the Institute for Water Resources (IWR), and on analysis by NED staff.

No significant new data collection efforts will be undertaken. Most likely, the availability of data will be uneven throughout New England. Lack of data is of concern to the extent that there is a possibility that those data would change the recommendation from this study. If and when NED staff suspect that might be true, they should discuss that possibility with IWR so that a joint decision can be made on how to proceed.

Vulnerability. NED will estimate the vulnerability of the New England states to drought impacts related to municipal and industrial water supply, wastewater treatment, and significant water based activities (agriculture, hydropower, recreation, and fish and wildlife).

Vulnerability should be analyzed and reported by state, with additional analysis for significant metropolitan areas. Vulnerability to drought should be expressed in terms of the expected frequency, duration and magnitude of drought and the extent to which plans have been made and tested to mitigate drought impacts. Cities and states should divided into three groups: those which are demonstrably unlikely to be significantly impacted by drought; those which are demonstrably vulnerable; and those about which existing knowledge is insufficient to determine the level of vulnerability.

Demonstrably vulnerable cities should be ranked or grouped in some rough order or classes of vulnerability.

The factors in the evaluation could include:

a. meteorological statistics;

b. ground and surface water storage capacity available;

c. soil and soil moisture characteristics;

d. major and minor water transmission networks;

e. water rights, marketing, and allocation schemes;

f. the adequacy of drought contingency plans;

g. existing projections of municipal water demand and supply.

h. existing water supply contracts;

i. environmental (in-stream) requirements;

j. pertinent hydrologic indicators, such as the ratio of the 20 year flow to the 1 year flow (an indication of flow variability) or the ratio of storage capacity to flow for one year (an indication of ability to endure water use which exceeds flow), or the ratio of annual use to safe yield.

IWR will provide similar types of information for other parts of the country as a basis for comparison.

NED should report on the general preparedness of the local, regional, and state governments, as well as significant water supply and hydroelectric utilities, including (1) the availability and soundness of drought contingency plans, and (2) the use of long term adjustments to drought.

Regional Willingness to Participate in the Study. NED will determine whether the regions most vulnerable to drought are interested in pursuing a joint regional project under the National Study of Water Management During Drought in FY 92 and FY 93.

During FY 91, NED will speak to representatives of New England states and regions to obtain information on drought vulnerability. Those discussions will also provide an opportunity to assess how interested the states or regions would be in further collaboration. Work in the following two years would probably consist of actions to determine what should be done to address the vulnerability of the region to drought, the "actions" would be compatible with the approach to addressing regional drought problems which was designed for the Drought Preparedness Studies being conducted in other regions of the U.S. as a part of the National Study of Water Management During Drought. NED should inform the regions of the possibility of further work and the three criteria for site selection (vulnerability, willingness, and value to the national study).

An Outline for the New England Drought Vulnerability Study
the FY91 New England Division Study for the
National Study of Water Management During Drought

Value to the National Study. NED and IWR will jointly evaluate the value which potential regional projects in FY 92 and FY 93 would have for the National Study of Water Management During Drought.

The drought problems in the New England region are significant and sometimes unique. Addressing these problems is essential to the completeness of the National Study of Water Management During Drought. Some of the features found in New England which need to be addressed are the greater than typical reliance on surface water; unique "New England" approaches to Federal/state/regional/local water management partnerships; the physical reliability of aging infrastructure; the relative brevity of historic droughts compared to other parts of the country (and the consequently low ratio of stored water to daily use); the unique application of conservation methods and technology with relatively old buildings and plumbing; and the lack of "safety margins" for M&I water supply provided in other areas by the potential for reallocation of water from agricultural or other uses, from groundwater, or from surface water which requires treatment before use.

STATE OF MAINE
OFFICE OF THE GOVERNOR
AUGUSTA, MAINE
04333

JOHN R. MCKERNAN, JR.
GOVERNOR

April 10, 1990

Robert W. Page, Assistant Secretary
Department of the Army
Washington, D.C. 20310-0103

Dear Mr. Page:

In response to your letter of March 19th, this is to let you know that, in the Spring of 1989, I assigned responsibility for drought planning to the Director of the Maine Emergency Management Agency, David D. Brown. His agency established a Drought Task Force (see attached list) and coordinated the preparation of a draft Drought Contingency Plan for the State of Maine. Included in that plan were: a policy statement; a clear definition of drought levels (utilizing the Palmer index); actions to be taken at each level; and the assignment of responsibility for those actions.

Drought is not normally a major concern in Maine. The state is blessed with consistently significant annual rainfall. Should we experience an extended dry period, our major concerns would be: 1. agricultural damage; 2. forest fires; 3. river pollution (due to the large number of industries which discharge waste material, and a decrease of flow in dry periods; 4. damage to aquatic biology (due to both the decreased flow and the increased pollution); and 5. decreased water supply for both power production and citizen consumption.

I have asked Mr. Brown to serve as the point of contact for further information and coordination of drought-related matters. His address is State House Station #72, Augusta, Maine 04333 (tel: 207-289-4080).

Sincerely,

John R. McKernan, Jr.
Governor

JRM:hrd

enclosure

Attachment B

MEMA MEETING SIGN-IN SHEET

DATE: April 25, 1989 TIME: 9:00 a.m.

MEETING: Drought Planning

NAME	AGENCY/ORGANIZATION	PHONE NO.
Dave Brown	Director, MEMA	289-4080
Rex Grover	Bangor Hydro	945-5621 X 264
Marc Loiselle	ME Geological Survey	289-2801
Derrill Cowing	USGS	622-8201
Paul W. Dutram	State Planning Office	289-3261
Dave Staples	USDA	581-3470
Mike Pomerleau	MEMA	289-4094
Richard Morse	Maine Forest Service	289-4992
John DelVecchio	DECD	289-6800
Ray Hammond	PUC	289-3831
William R. Donovan	Maine National Guard	626-4313
John McPherson	Union Water Power Co.	784-4501
Vernard J. Kavanaugh	Georgia Pacific	427-6917
Frank W. Ricker	Soil & Water Cons. Comm.	289-2666
Robert Clark	ME Dept. of Agriculture	289-3841
Thomas Hawley	NWS	773-0352
Lynn Taylor	MEMA	289-4100
Allen Corson	Kennebec Water Power Co.	872-6624
John Kennelly	Corps of Engineers	(617) 647-8255

DATE: April 25, 1989 TIME: 9:00 a.m.

MEETING: Drought Planning

NAME	AGENCY/ORGANIZATION	PHONE NO.
Barbara Notini	Corps of Engineers	(617) 647-8544
Darla S. Chafin	MEMA	289-4080
Charles Rossoll	DHS/Health Engineering	289-5681

ROSTER\MYPLNG.ROS

STATE OF NEW HAMPSHIRE

OFFICE OF THE GOVERNOR

JUDD GREGG, GOVERNOR

May 2, 1990

Mr. Robert W. Page
Assistant Secretary of the Army
Civil Works
Department of the Army
Office of the Assistant Secretary
Washington, D. C. 20310-0103

Dear Mr. Page:

Thank you for your letter of March 19, 1990 requesting that I designate a point of contact for coordination of drought related matters as they pertain to the National Water Management During Drought Study.

I would like to designate the following individual to serve in that capacity:

Mr. Delbert Downing, Executive Director
Division of Water Resources
64 North Main Street
Concord, New Hampshire 03301
(603)271-3406

Please feel free to contact Mr. Downing directly with any information you have regarding the study.

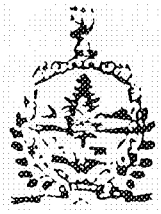
Sincerely,

Judd Gregg
Governor

JG:cc
cc: Mr. Delbert Downing

Attachment C

MADELEINE M. KUNIN
GOVERNOR



STATE OF VERMONT
OFFICE OF THE GOVERNOR
109 STATE STREET
MONTPELIER, VERMONT 05602
(802) 828-3333

April 18, 1990

Mr. Robert W. Page
Assistant Secretary of the Army
Department of the Army
Washington, D. C. 20310-0103

Dear Mr. Page:

I am pleased to know that the Army Corps of Engineers is undertaking a study to assess the effectiveness of the nation's drought management strategy during a drought.

Vermont is interested in cooperating with the Corps of Engineers in this effort. I have designated Mr. George Lowe to be the point of contact in this study for the State of Vermont. Mr. Lowe's address and telephone number are:

Department of Public Safety
Emergency Management Division
Waterbury Complex
Waterbury, VT 05676
802-244-8721

Mr. Lowe is knowledgeable on drought issues and will be able to assist you in developing information on local priorities.

Sincerely yours,

Madeleine M. Kunin
Governor

MMK:gh

cc: Jonathan Lash, Secretary, Agency of Natural Resources
George Lowe, Director

Attachment D

State of Rhode Island and Providence Plantations
EXECUTIVE CHAMBER, PROVIDENCE

Edward D. DiPrete
Governor

April 11, 1990

The Honorable Robert W. Page
Assistant Secretary of the Army
(Civil Works)
Office of the Assistant Secretary
Washington, DC 20310-0103

Dear Mr. Page:

In response to your letter concerning the National Water Management During Drought Study, please know that Rhode Island is in the process of developing a statewide water plan to include management water guidelines. Plan development is the responsibility of the Division of Planning of the Rhode Island Department of Administration.

The requested point of contact is Robert K. Griffith, Jr., Office of Strategic Planning, who also acts as Executive Director of the Water Resources Coordinating Council, an inter-agency task force which is advising me on all matters relating to water policies. Mr. Griffith can be reached at the Rhode Island Department of Administration, Office of Strategic Planning, One Capitol Hill, Providence, Rhode Island 02908-1220. His telephone number is 401-277-1220.

Sincerely,

Edward D. DiPrete

Edward D. DiPrete
Governor

Attachment E

STATE OF CONNECTICUT
EXECUTIVE CHAMBERS
HARTFORD, CONNECTICUT 06106

WILLIAM A. O'NEILL
GOVERNOR

CLASSIC CONNECTICUT

April 2, 1990

Mr. Robert W. Page
Assistant Secretary of the Army
Department of the Army
Washington, D.C. 20310-0103

Dear Mr. Page:

This is to acknowledge receipt of your letter concerning the Army Corps of Engineers' National Water Management During Drought Study.

Per your request, I am designating Joan Maloney, Under Secretary for Comprehensive Planning, Office of Policy and Management, as the state's contact person. She can be contacted as follows: Joan K. Maloney, Under Secretary for Comprehensive Planning, Office of Policy and Management, State of Connecticut, 80 Washington Street, Hartford, Connecticut 06106, Phone: (203) 566-4298.

The State of Connecticut looks forward to being an active participant in the study.

Sincerely,

WILLIAM A. O'NEILL
Governor

Attachment F

MASSACHUSETTS WATER RESOURCES AUTHORITY
Charlestown Navy Yard
100 First Avenue
Boston, Massachusetts 02129

Telephone: (617) 242-6000
Facsimile: (617) 241-6070

August 19, 1991

Mr. Joseph L. Ignazio
Director of Planning
Panning Directorate
Planning Formulation Division
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Dear Mr. Ignazio:

Thank you for your letter of August 7, 1991. The Massachusetts Water Resources Authority would be please to participate in the New England Drought Study.

In February of 1989 the MWRA submitted a request to the Massachuseets Department of Environmental Protection for a Declaration of Water Supply Emergency because of the low storage capacity of Quabbin Reservoir. Subsequently, a detailed Drought Management Plan was prepared in conjunction with the MDC and submitted to MDEP. Since the creation of the MWRA, demand management has been a priority and we are proud of the achievements in reducing demand on the system.

We look forward in working with you on this Drought Study. The point-of-contact in the Waterworks Division is Marcis Kempe, Director, Resources Conservation & Management.

Sincerely,

William A. Brutsch
Director, Waterworks Division

cc: P. Levy
M. Kempe

Attachment G